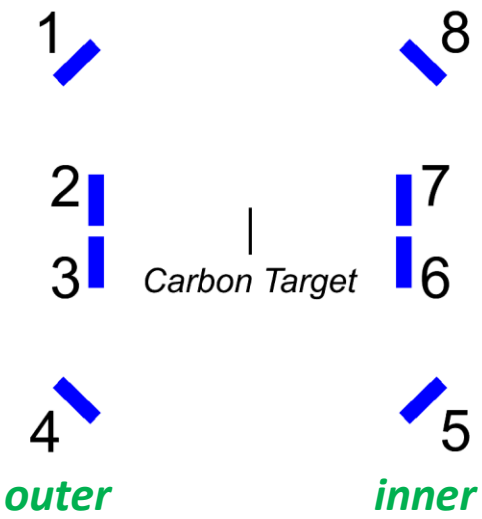
A. Poblaguev

Determination of t0 from the prompt events

- *A method*
- *Experimental tests at AGS*
- *Induced pulses*

AGS CNI Polarimeter 2012



4 different detector types:

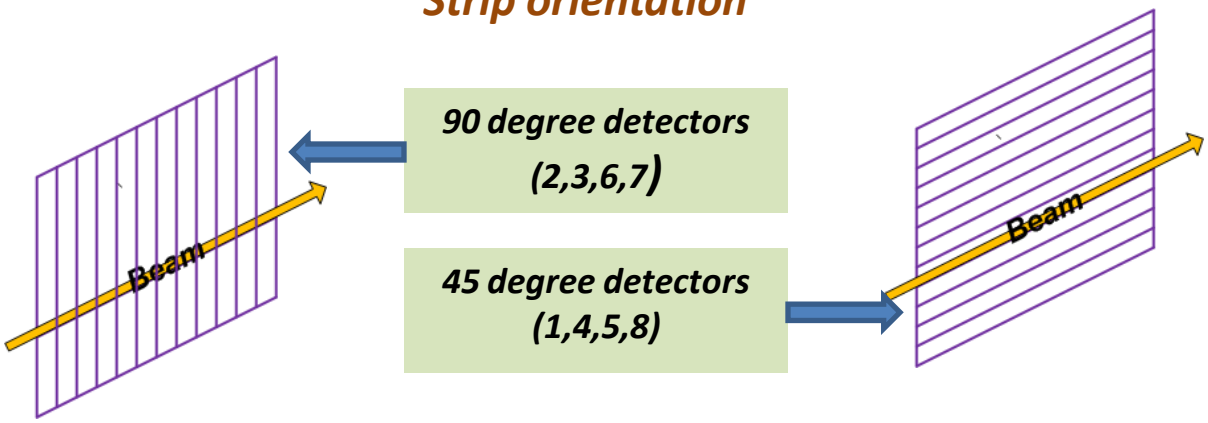
1,8 - Hamamatsu, slow preamplifiers, L = 51 cm

2,7 - BNL 2mm, fast preamplifiers, L = 30 cm

3,6 - BNL 1 mm, fast preamplifiers, L = 30 cm

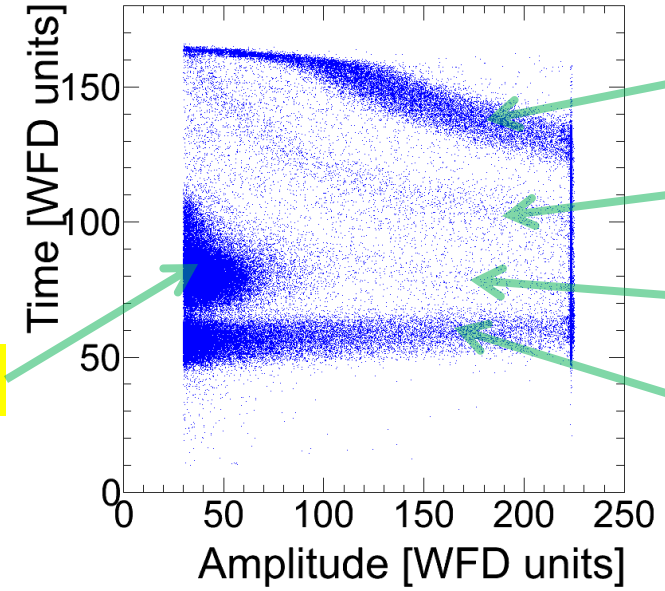
4,5 - Hamamatsu, fast preamplifiers, L = 51 cm

Strip orientation



Prompt Events. Run 51969. Low Intensity ≈0.3.

Hamamatsu, Strip 0



?

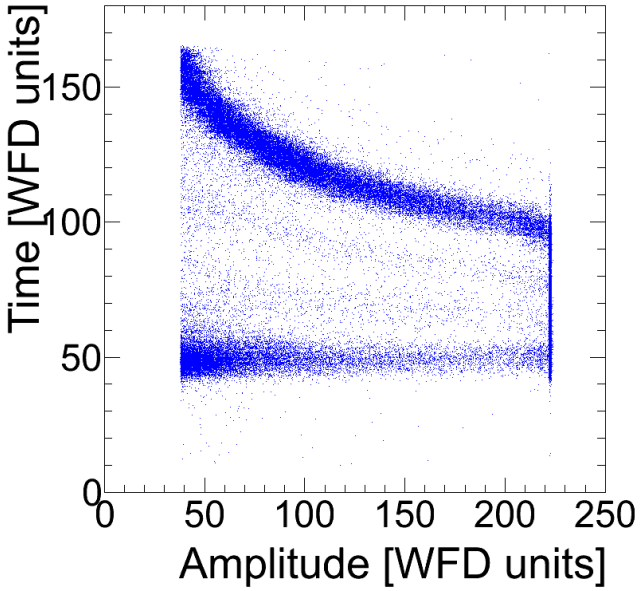
Low energy carbons (“banana”)

Alpha (?)

Low energy protons (?)

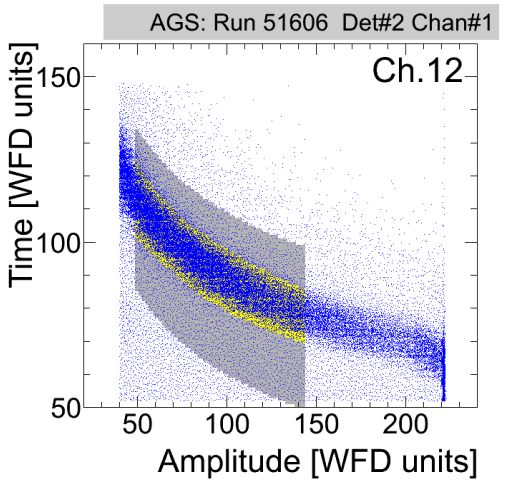
Fast π and p

BNL 2 mm, Strip 12



We can try to use fast π and p to measure t0

Standard Calibration of p-Carbon Detectors



$$E_{\mathrm{kin}} = \frac{Mv^2}{2}$$

$$\alpha A + E_{\mathrm{loss}}(\alpha A, x_{\mathrm{DL}}) = \frac{0.5ML^2}{(t-t_0)^2}$$

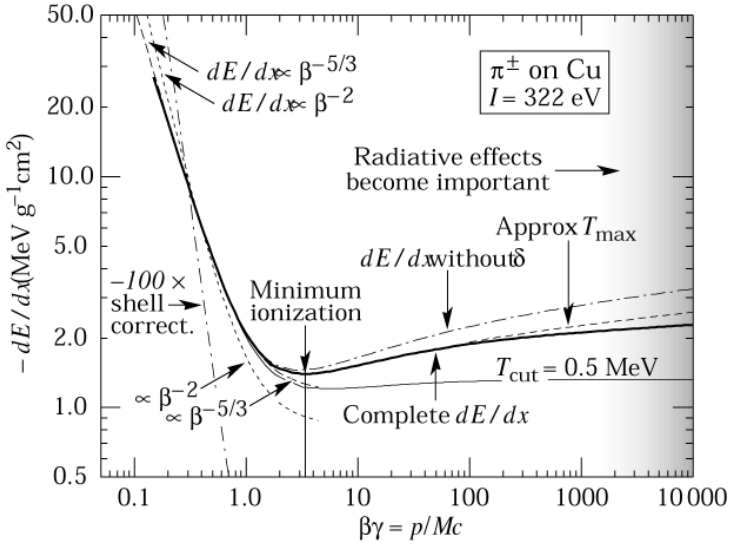
E_{loss} is derived from known stopping power dE/dx

- If t_0 is known then detector may be calibrated in a model independent way

$$E_{\mathrm{kin}}(A) = \frac{0.5ML}{(t_A - t_0)^2}$$

  where t_A is mean measured time for amplitude A.
- If effective dE/dx is well parameterized then all calibration parameters α, t_0, x_{DL} may be determined in data fit
- In reality, we measure α in alpha-calibration and determine t_0, x_{DL} in a fit
- Even a small discrepancy in effective dE/dx parameterization may result in substantial error in determination of t_0 and x_{DL}. We have no good method to verify the quality of calibration.
- Error in value of t_0 of about *5 ns* results in about 10% error in measured polarization .

Bethe-Bloch formula

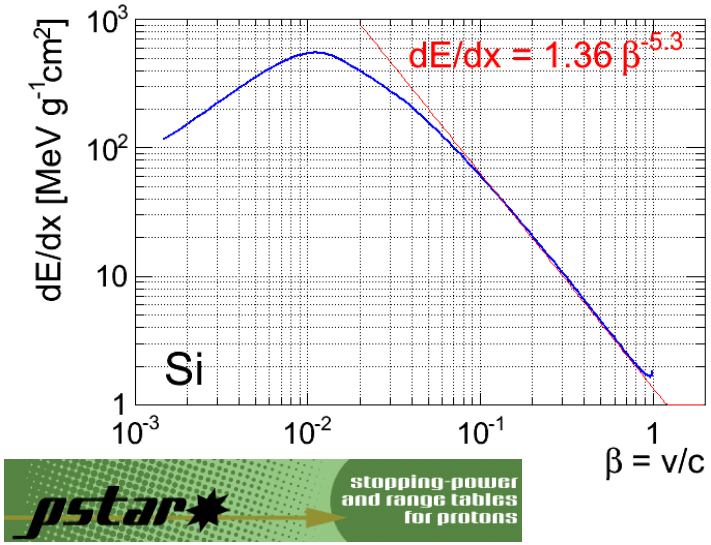


$$-\frac{dE}{dx} = \kappa z^2 \cdot \frac{Z}{A} \cdot \frac{1}{\beta^2}\left[\frac{1}{2}\ln\frac{2m_e c^2\gamma^2\beta^2}{I^2}E_{\text{kin}}^{\max} - \beta^2 - \frac{\delta}{2}\right]$$

$$dE/dx \propto \beta^{-2} \quad \text{(small } \beta\text{)}$$

More accurately:

$$dE/dx \propto \beta^{-5/3} \qquad (0.1 < \beta\gamma < 1)$$
$$(0.1 < \beta < 0.7)$$



Measured amplitude:

$$A = (dE/dx)\frac{\rho d}{\alpha} = \frac{1.36\rho d}{\alpha}\beta^{-5/3}$$

For d=300 μm and α=6.6 keV:

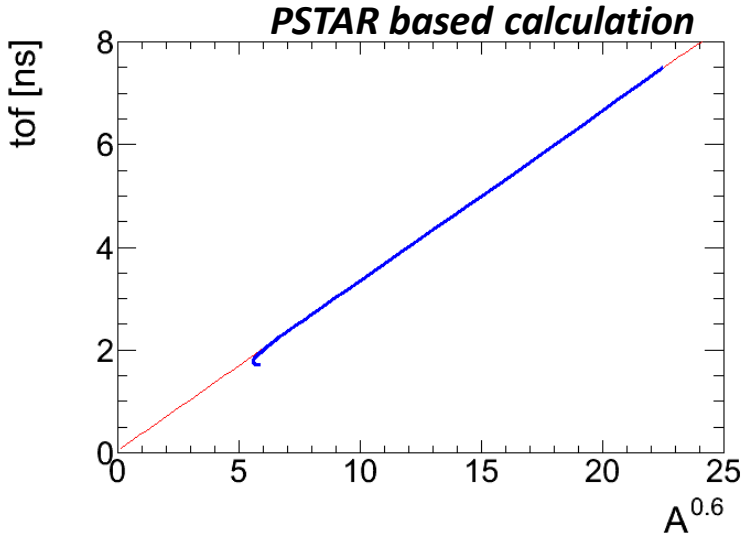
$$26 < A < 670$$

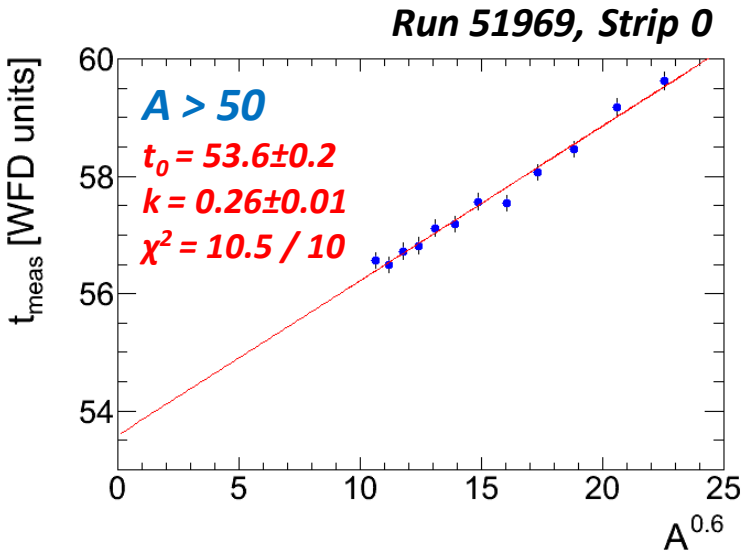
Time of flight:

$$\text{tof} = L/v = kA^{0.6}$$

$$k = \begin{cases} 0.34 \text{ ns} & \text{(Hamamatsu)} \\ 0.20 \text{ ns} & \text{(BNL)} \end{cases}$$

Data Fit





$$t_{\rm meas} = t_0 + kA^{0.6}$$

We do not need to know k to measure t_0 !
There is no tuning parameters at all (except for power 0.6)

$$t_0 = 53.6 \pm 0.2 \;\Rightarrow -23.0 \pm 0.2 \text{ ns}$$

Compare with standard calibration value:

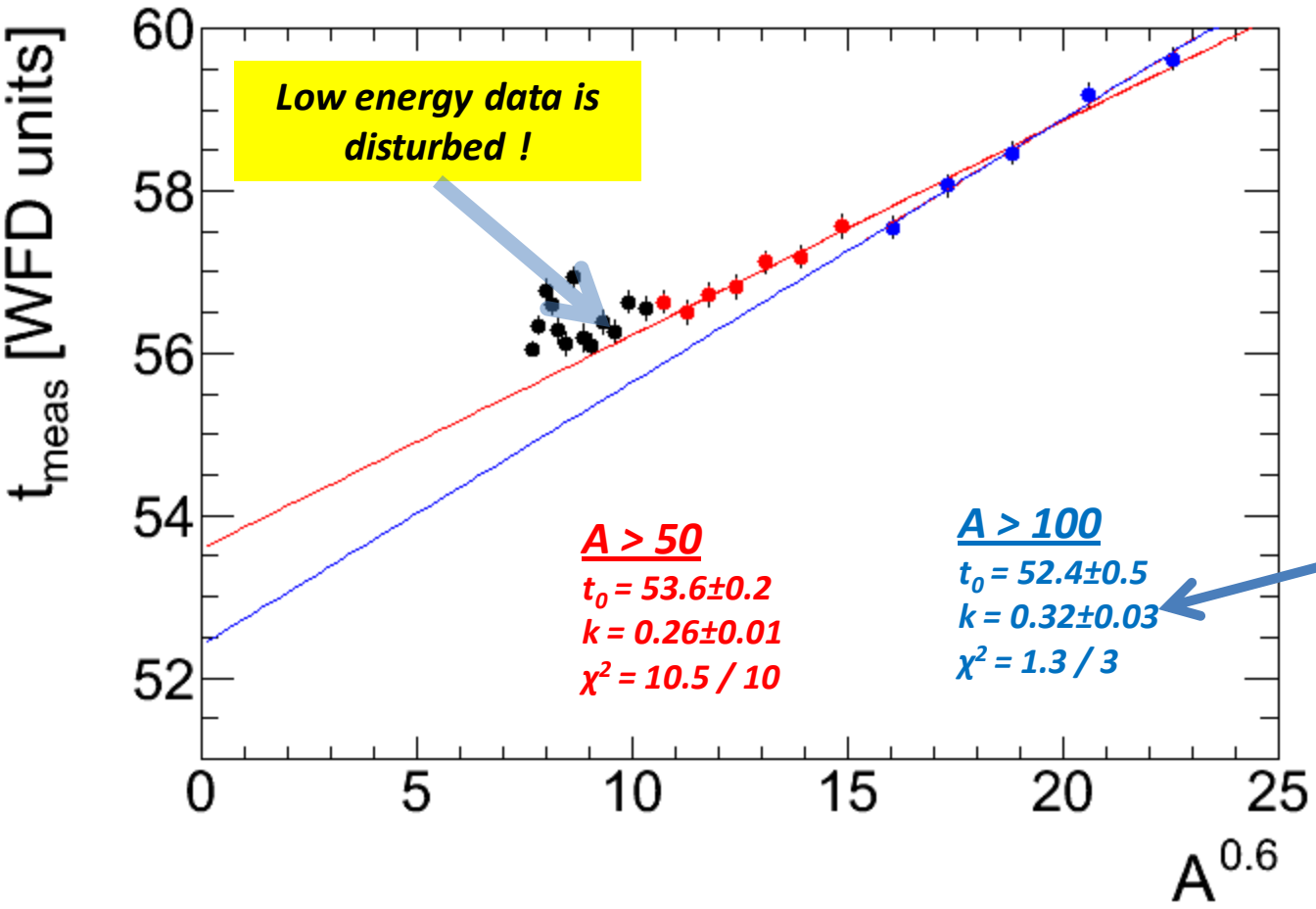
$$t_0^{(\rm cal)} = -23.4 \text{ ns}$$

Perfect agreement, but , in fact, the consistency is within *few ns* only, because t_0 is unstable at AGS.
My estimate (unverified yet) gives:

$$\delta t_0 \approx 2 \text{ ns}$$

$$k = 0.26 \;\Rightarrow\; d \approx 450\ \mu\text{m} \quad ???$$

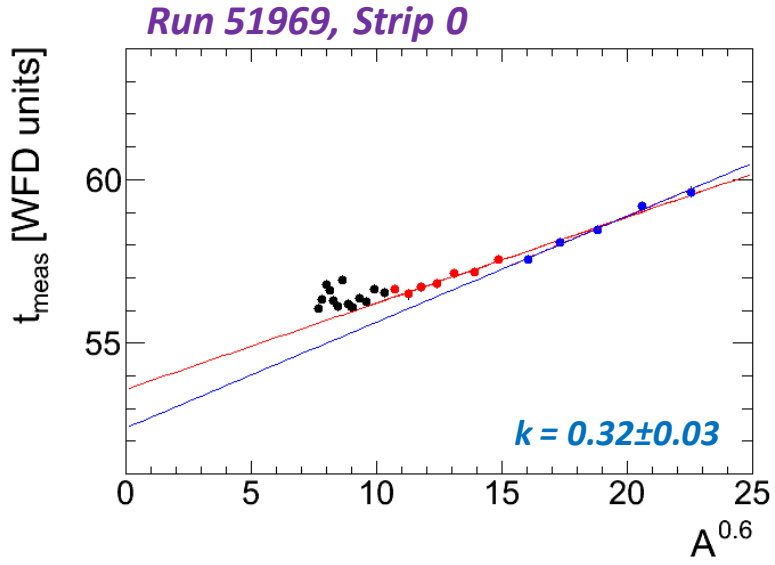
More accurate analysis

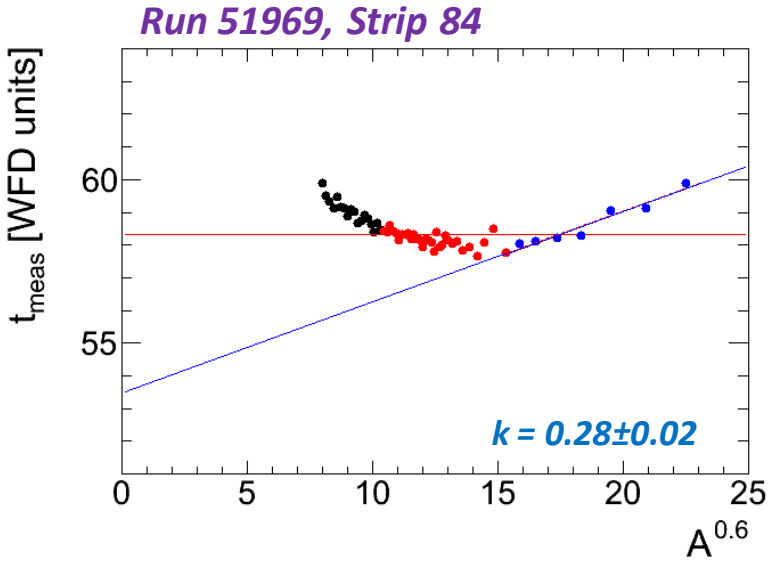


Quality of data fit is well controllable

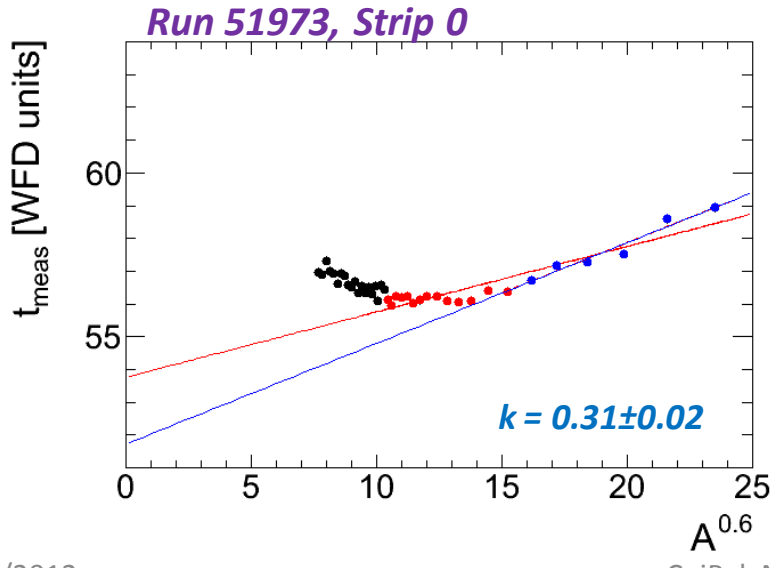
Comparison of outer/inner Hamamatsu detectors

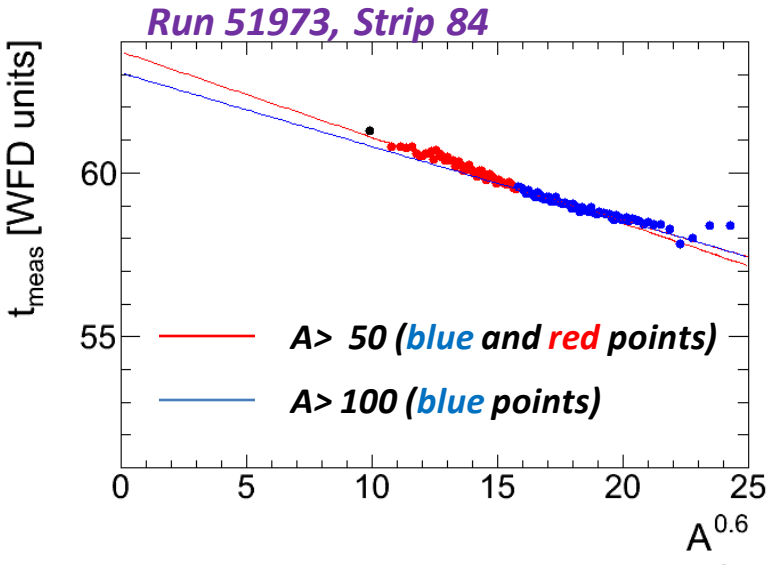
Beam Intensity 0.33





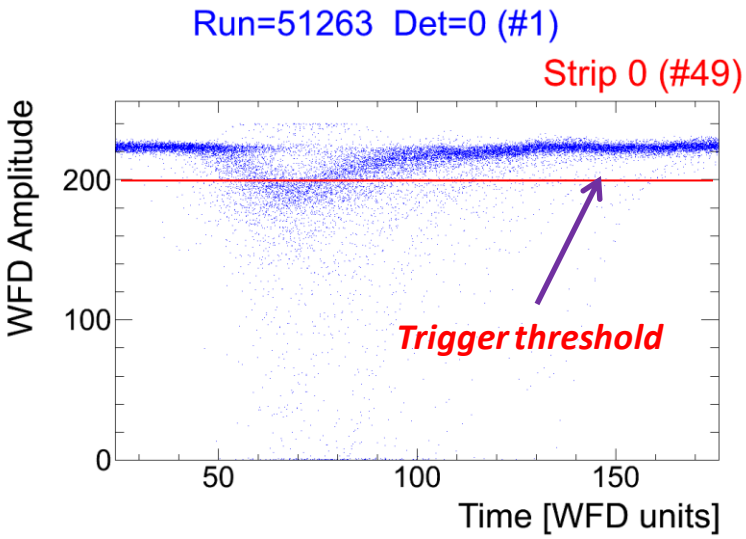
Beam Intensity 1.33

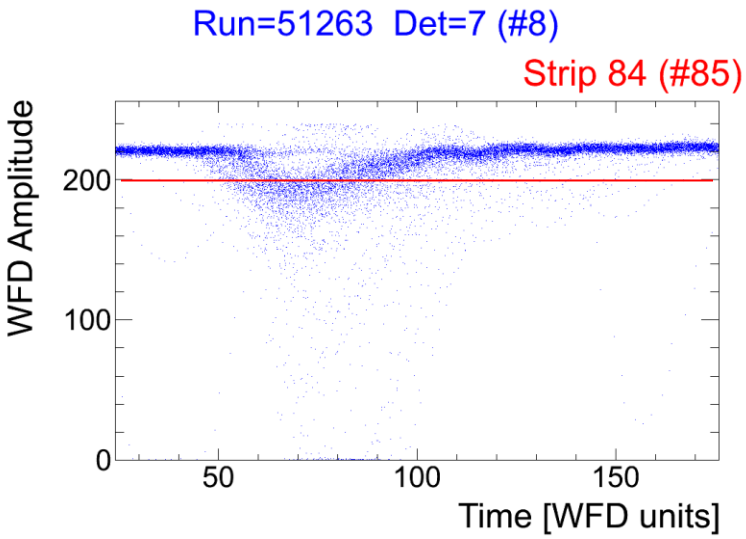




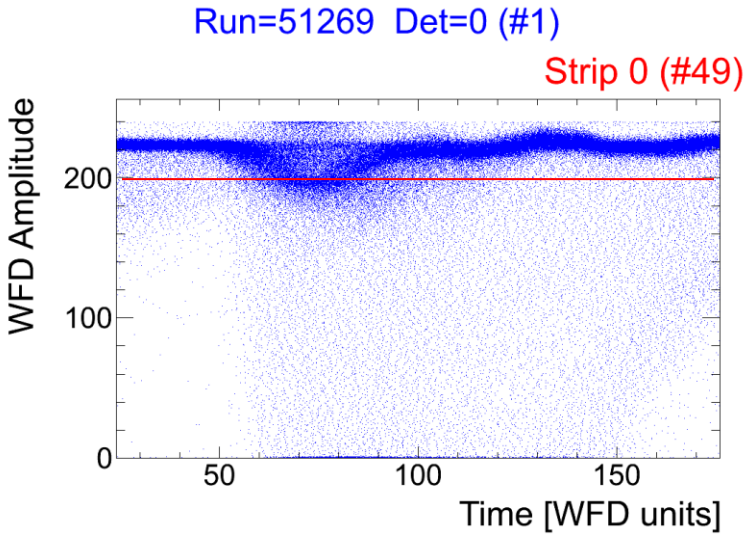
Superimposed waveforms. Beam Intensity ≈0.5

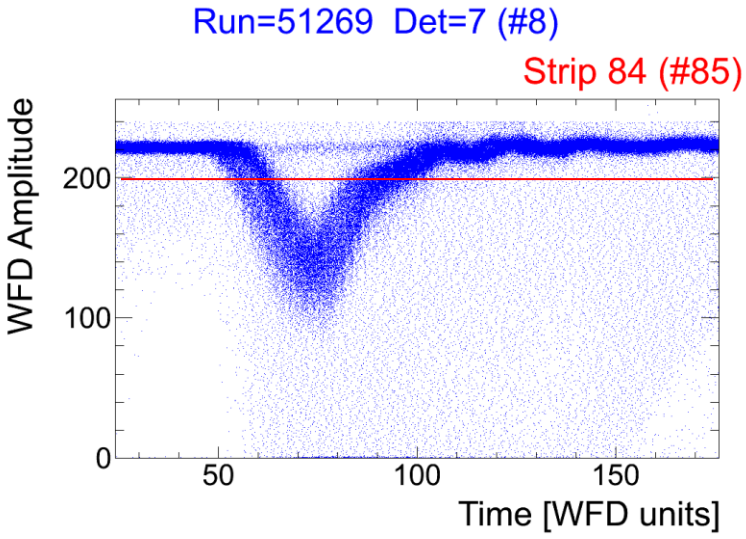
No Target





Target V2

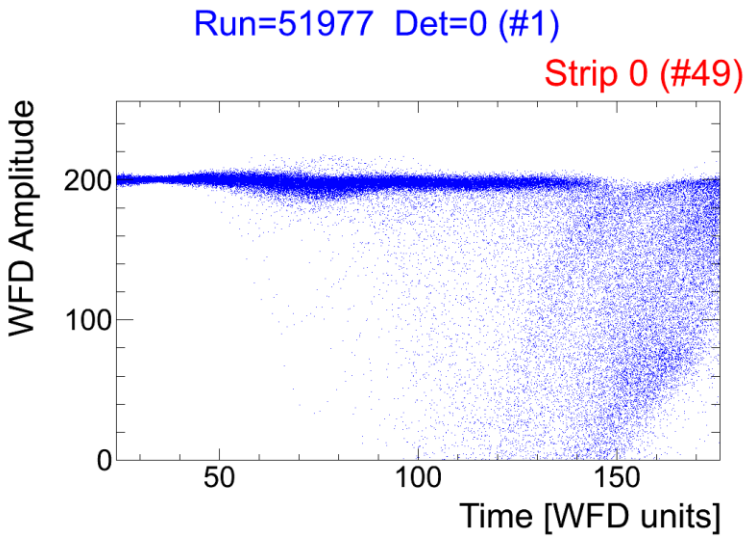


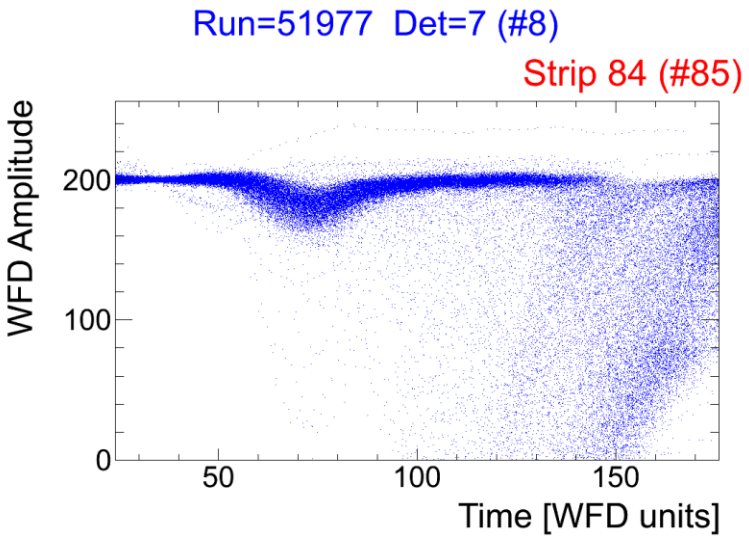


Superimposed Signals

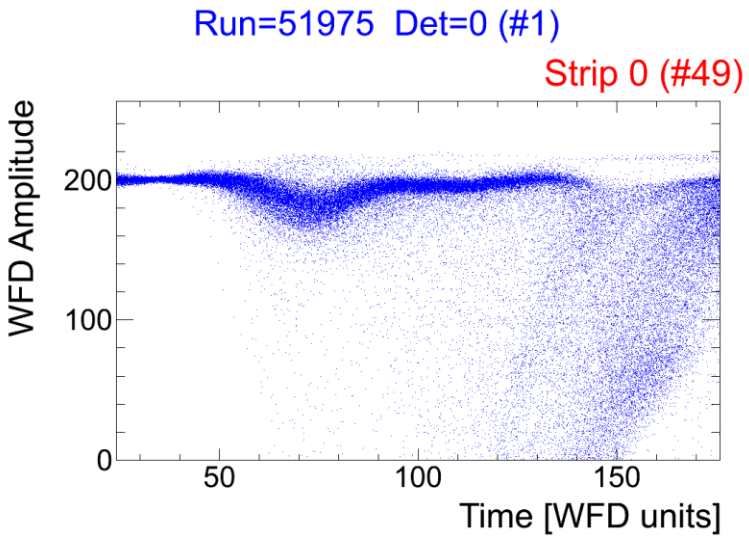
Trigger at Time>150 ***Pedestals were adjusted to 200***

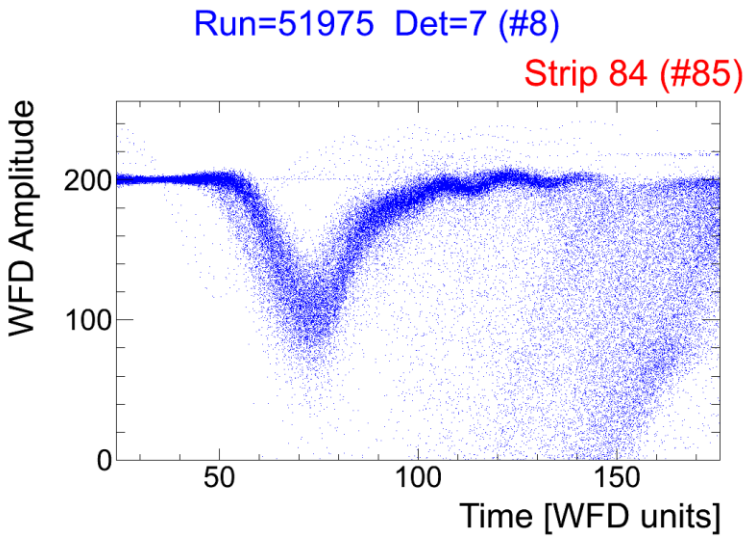
Beam Intensity 0.2





Beam Intensity 1.4

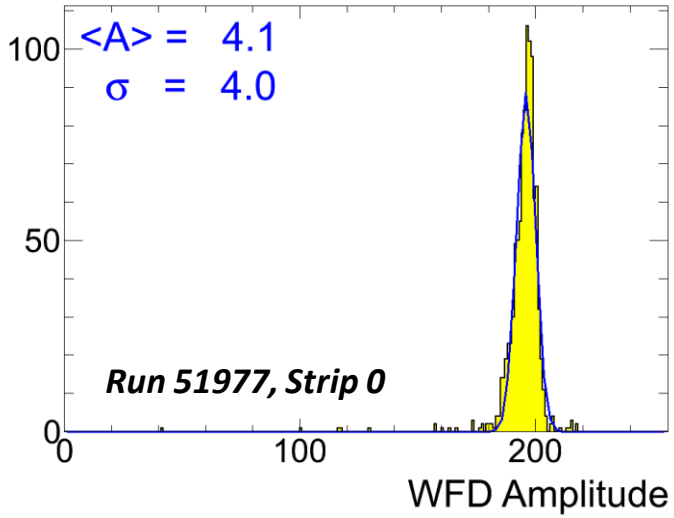


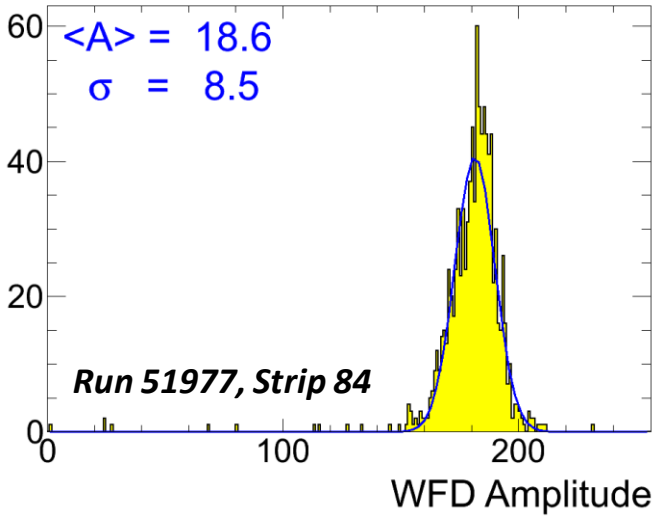


Induced Pulse Amplitudes

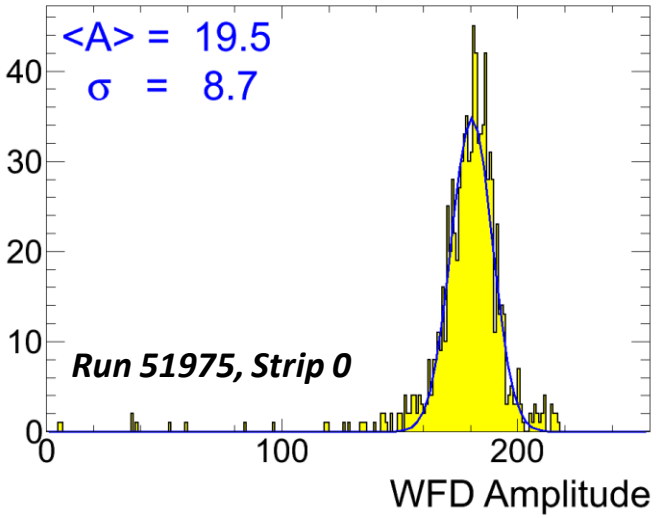
Trigger at Time>150 ***Pedestals were adjusted to 200***

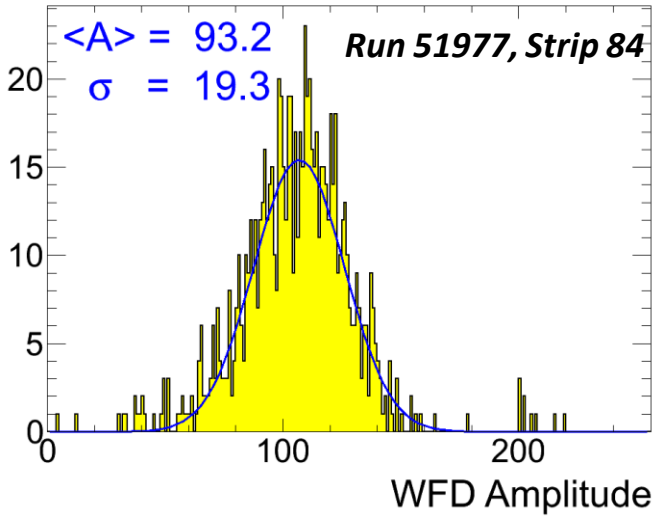
Beam Intensity 0.2



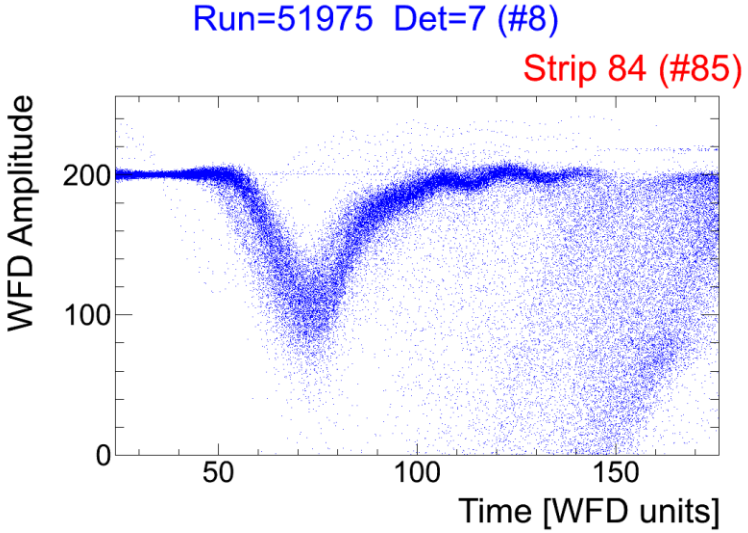


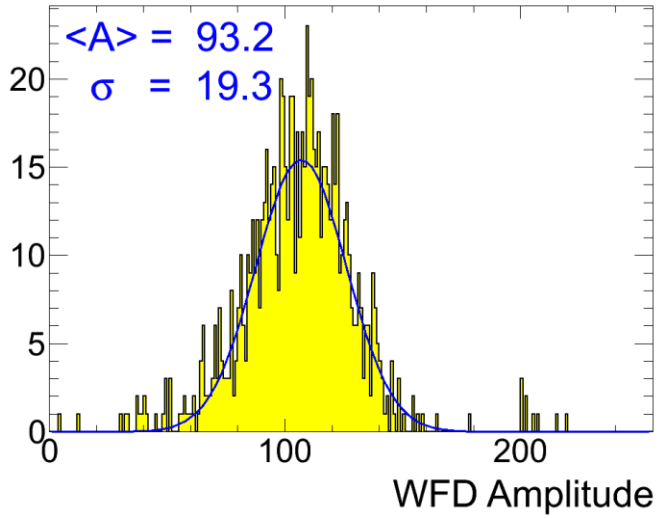
Beam Intensity 1.4





What Pulse do we observe in inner detectors ?





- **Seen only in inner detectors**
- **Not seen without target**
- **Constant amplitude**

The only explanation I can suggested is that we see multiple hits by halo protons (produced by primary beam interaction with target)

But there is a disagreement in estimate of number of hits per bunch:

$$\langle N \rangle < \frac{\langle A \rangle}{A_{\mathrm{MIP}}} \approx 6$$

$$\langle N \rangle > \left(\frac{\langle A \rangle}{\sigma} \right)^2 \approx 24$$

Summary

- ***A method to measure t0 was suggested.***
- ***Theoretically it must be very accurate and very reliable.***
- ***Experimentally, an interference with induced pulses may degrade the method.***
- ***At moment, satisfactory results were obtained only for outer Hamamatsu (45 deg.) detectors.***
- ***More study is needed for other detectors.***
- ***Study of induced pulses should be continued.***
- ***It is very interesting to test the method at RHIC.***